March 28, 1961 G. GEPPERT 2,977,091

BUCKET WHEEL

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Fig.1

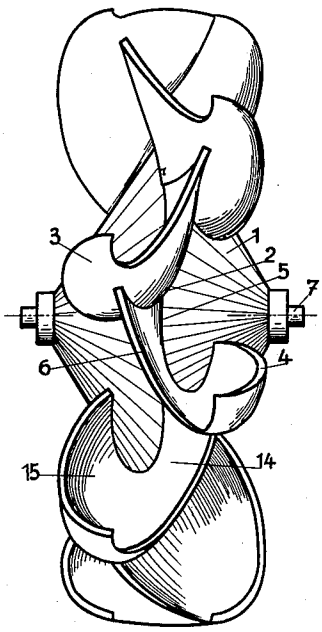

Fig.2

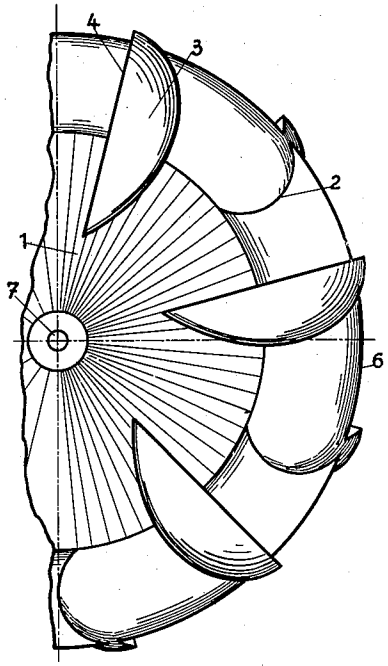

Fig.3

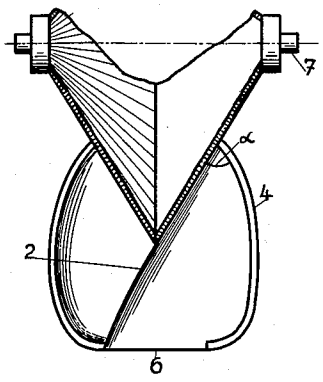

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Fig.4

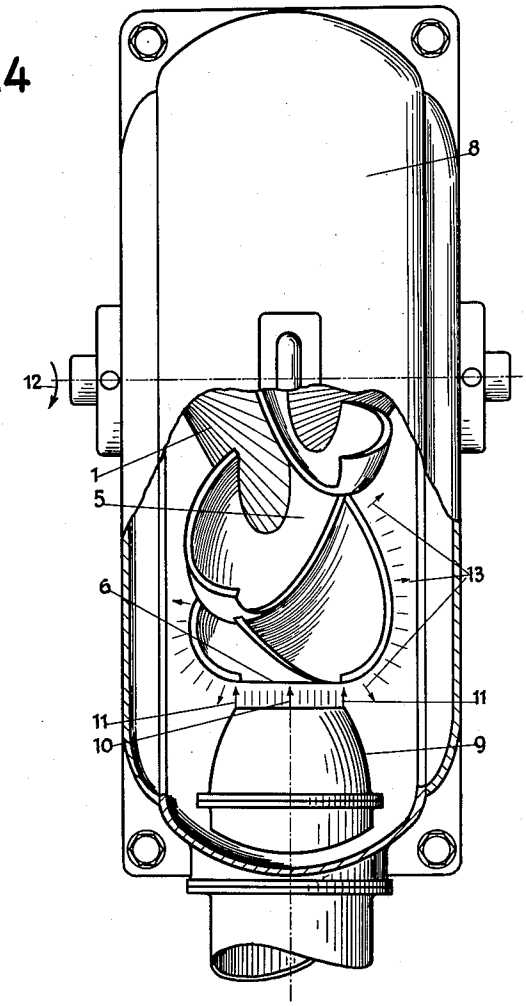

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Fig.5

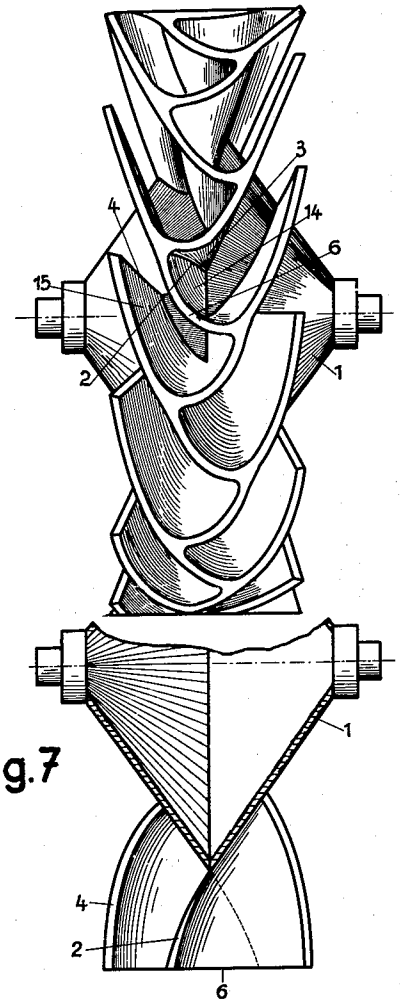

Fig.6

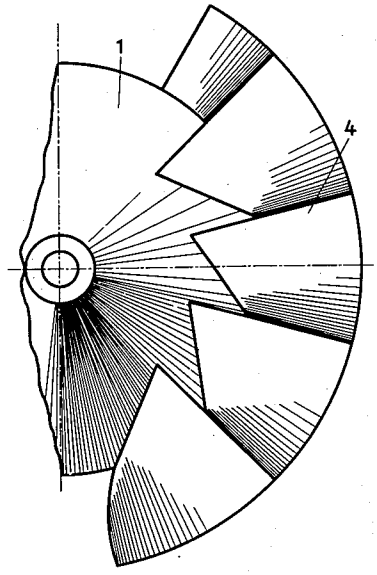

Fig.7

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Fig.8

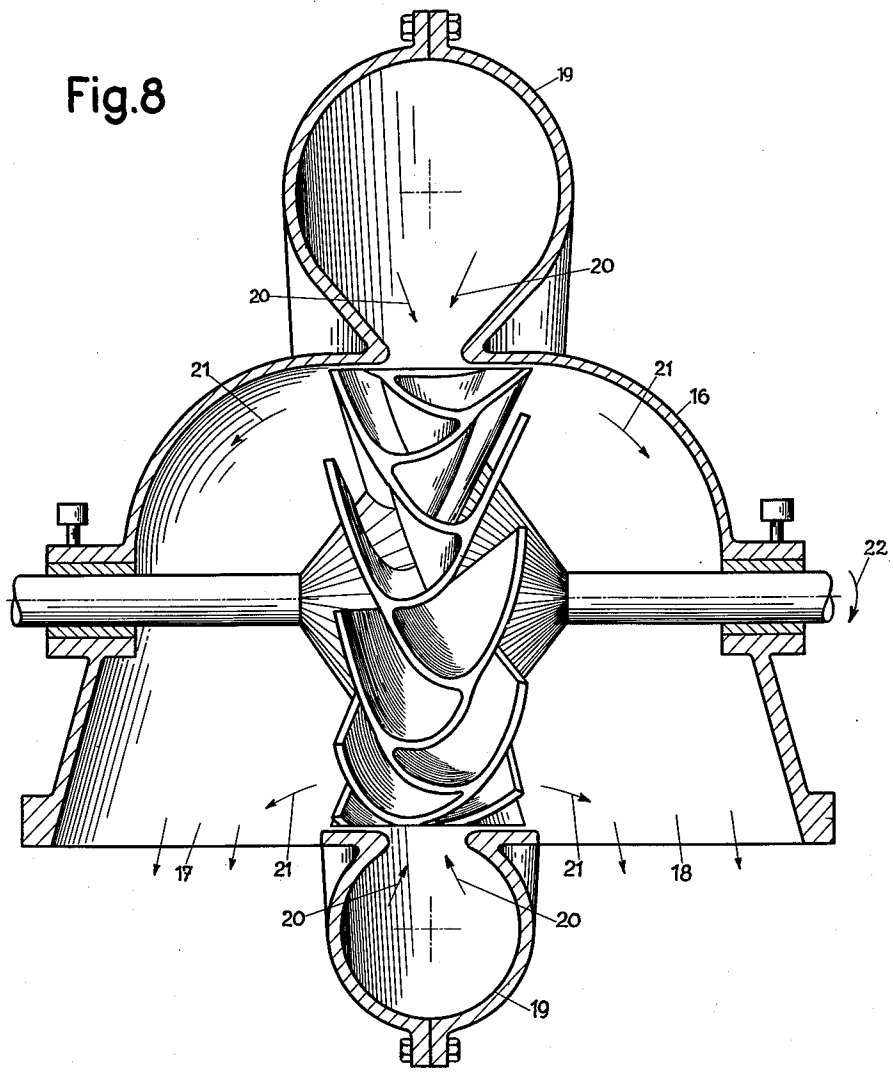

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Fig.9

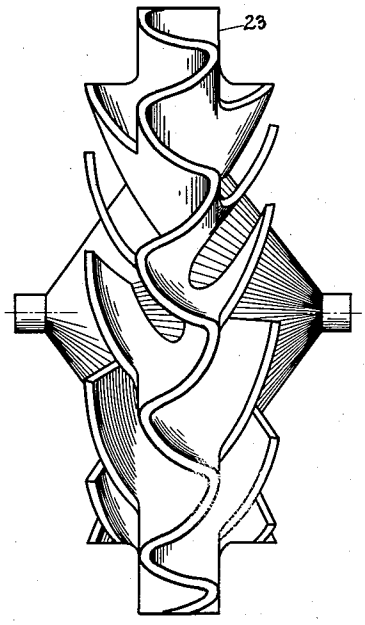

Fig.10

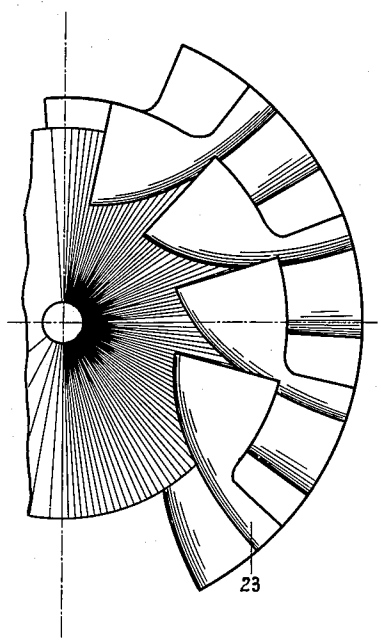

Fig.11

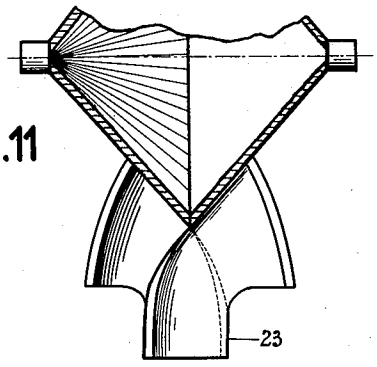

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Fig.12

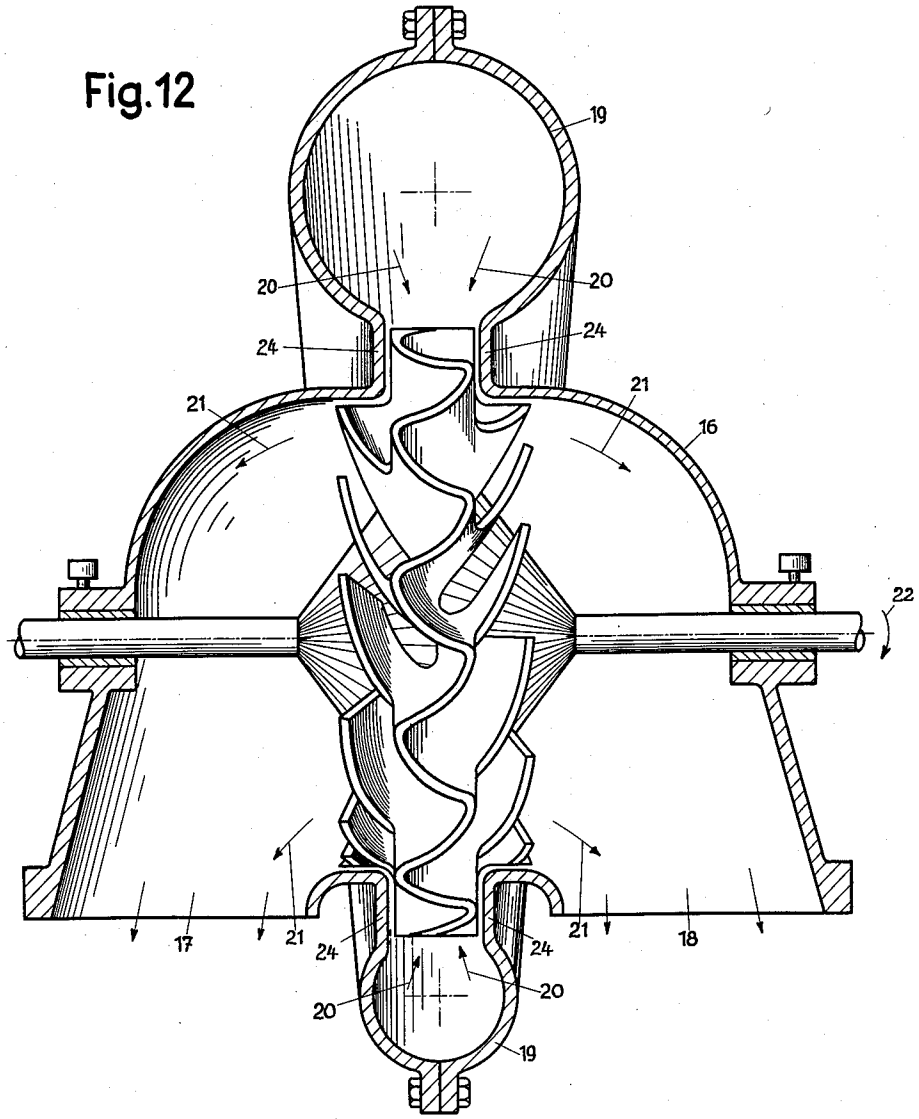

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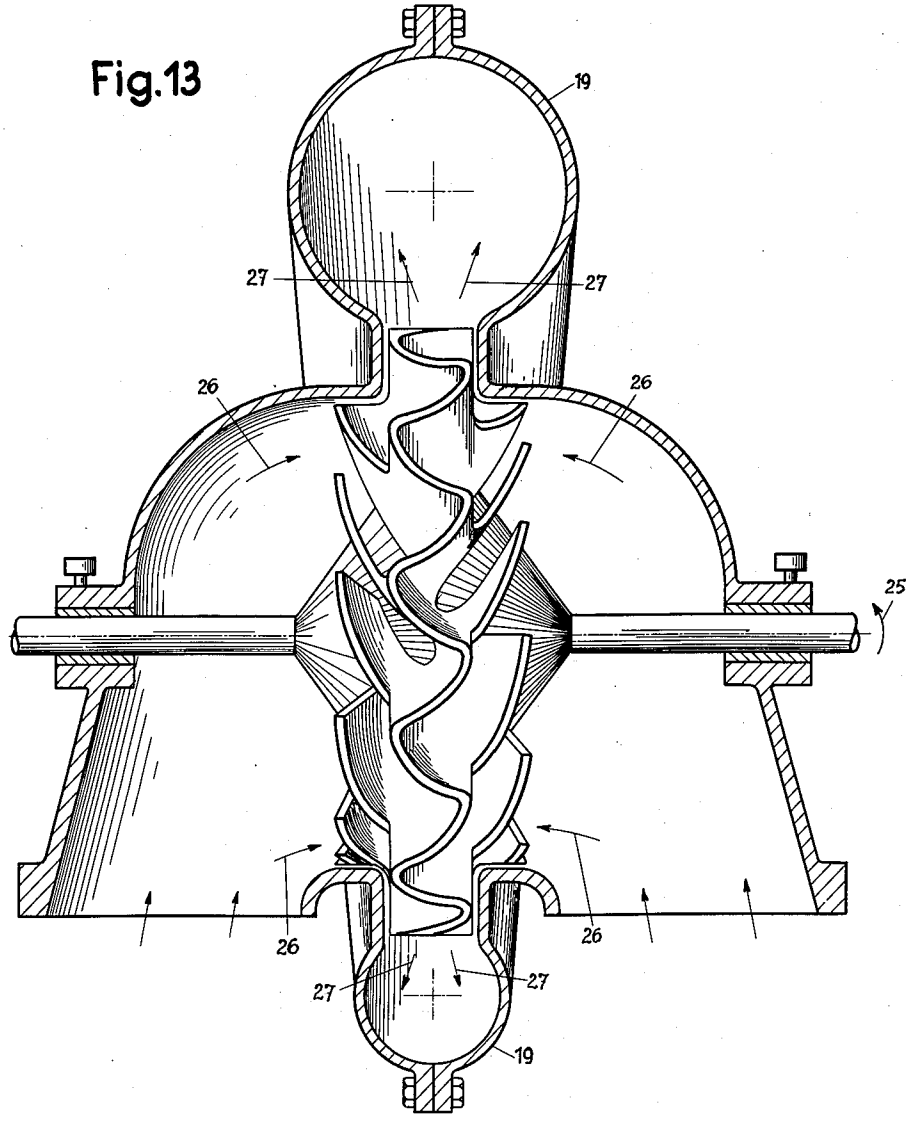
Fig.13



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2,977,091

BUCKET WHEEL

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6 Claims. (Cl. 253—116)

The invention relates to a bucket wheel with open buckets disposed at the periphery of a carrier disc and alternately directed toward each side of the wheel.

When applied to a free jet turbine it is the object of the invention that the bucket wheel should support the bending moment of the buckets, which is given by the product of the jet pressure with the distance from the jet centre to the bucket foot or root or to the fixing point of the bucket, hence sparing the hitherto customarily used stiffenings, strengthenings, ribs and other safety devices.

A further object of the invention is to provide an impeller for free jet turbines with as high a specific rate of revolutions as possible.

Moreover, another object of the invention is to provide a bucket wheel for free jet turbines, the buckets of which can easily be manufactured of sheet metal by pressing method.

Also when applied to a reaction turbine or to a centrifugal pump the bucket wheel of the invention is intended to support the bending moment produced by the hydraulic forces impacting on the buckets.

It is also intended to avoid to a large extent oscillations being originated, which are likely to be the cause of fractures.

The invention essentially consists in a bucket wheel with open buckets disposed on a carrier disc and alternately directed toward each side of the wheel, the inner limiting edge of each bucket being connected to the back of the following bucket.

This step supplies an important improvement in technical stability compared with the known constructions. The bending moment created by the jet pressure on the buckets in relation to the fastening point on the wheel is supported by the following and preceding bucket.

The advantages in technical stability are particularly great if the connection of the buckets is continuous from the inlet peripheral knife-edge up to the carrier disc and if the welded joints of the connection are in a zone free from any bending.

The invention is illustrated in more detail in the drawings, wherein

Figure 1 is a view in radial direction of one embodiment of a bucket wheel in accordance with the invention

Figure 2 is a view in axial direction of the same embodiment

Figure 3 is a paraxial section

Figure 4 is a top view of a bucket wheel according to Figures 1 to 3 applied as a carrier disc to a free jet turbine, the casing partially cut open

Figure 5 is a view in radial direction of another embodiment of a bucket wheel

Figure 6 is a view in axial direction and

Figure 7 is a paraxial section of same embodiment

Figure 8 is a side view with casing cut open of the bucket wheel according to Figures 5 to 7 used as a carrier disc for a reaction turbine

Figure 9 is a view in radial direction of a third embodiment of a bucket wheel

Figure 10 is a view in axial direction and

Figure 11 a paraxial section of same embodiment

Figure 12 is a side view with casing cut open of a bucket wheel according to Figures 9 and 10 used as a carrier disc for a reaction turbine and

Figure 13 is a side view with casing cut open of same bucket wheel used as a carrier disc for a centrifugal pump.

In the bucket wheel shown in Figures 1 to 3, there are provided open single-hollow buckets alternately directed toward each side of the wheel on the double-cone shaped carrier disc **1**.

The inner limiting edge **2** of each bucket lies on the rear **3** of the following bucket over its whole length.

The outer limiting edge **4** runs into the conical surface of the carrier disc **1**. The angle α between the tangent line of the outer limiting edge **4** at the point of intersection with the conical surface and the cone generatrix passing through the same point is, according to Figure 3, less than a right angle. The bucket surfaces are preferably so constructed that at their central inner portion **5** they pass as smoothly as possible into the conical surface of the carrier disc **1**.

As can be seen particularly from Figures 2 and 3, the peripheral knife-edges **6** of all the buckets lie on a cylindrical surface coaxial with the wheel axle **7**. As the knife-edges **6** of the bucket wheel lie at the outermost periphery, they are easily accessible and can be renewed in the simplest way by means of built-up welding and grinding.

As can be seen from Figures 1 to 3, only the bucket inner parts **14** have a peripheral knife-edge **6**. The bucket outer parts **15** are sloped outwardly at their periphery. With inner part **14** there is meant the portion of the bucket extending from the inner limiting edge **2** of the each bucket to the inner limiting edge **2** of the preceding bucket. The outer part **15** is the remaining portion of the bucket.

The inner surfaces i.e. the hydraulic effective surfaces of the bucket have their strongest curvature at the outer parts **15**. The inner parts **14** are but slightly inclined to the central plane of the carrier disc **1** normally lying on the wheel axle **7**. Consequently, the peripheral knife-edges **6** form a far displaying zigzag line.

The extension of the bucket inner parts **14** is in circumferential direction greater than that of the outer parts **15**.

The bucket wheel according to Figures 1 to 3 is able to be used as a carrier disc for a free jet turbine. As such, the bucket wheel is mounted in the usual way in a casing **8** as visible in Figure 4. The water free jet impulsing the bucket wheel flows from a nozzle **9** carried through the casing wall in direction of arrow **10**. Arrows **11** indicate the free jet width. This width is substantially of the same size as the axial breadth of the peripheral knife-edge **6**. According to Figure 4, the free jet impacts upon the lower half of the bucket wheel; under this admission the bucket wheel revolves in direction of arrow **12**.

After impacting upon the buckets or the peripheral knife-edge **6** the free jet separates into branch jets.

The branch jet flowing between the peripheral knife-edges **6** of two neighboring buckets is deflected by the single-hollow shaped bucket, whereby it exerts a hydraulic force upon the bucket and is discharged with as much energy so as not to cause an exit loss of energy beyond the tolerable value, in the absolute exit direction of the arrows **13**, along the outer limiting edge **4** of the bucket acting as outlet edge.

The resultant of the hydraulic forces acts approximately at the centre of the bucket which is just the place where the bucket is supported by the preceding bucket over the entire radial extent from the inlet knife-edge **6** down to the periphery of the carrier disc **1**. Through

this mutual connection of all buckets alternating toward each side and forming a bucket ring or wreath, closed up to the exterior diameter of the wheel, the neighboring buckets also take up a part of the peripheral or hydraulic forces exerted at a certain moment upon the bucket concerned.

Owing to this mutual stiffening of the buckets, the bucket feet or roots no longer have to take up any bending tensions, but only have to transmit the hydraulic and centrifugal forces onto the double-cone shaped carrier disc **1**.

Stiffening ribs are superfluous, thin wall-thicknesses can be selected, and the bucket ring or wreath can be welded directly to the axle collar, so that space and freedom are gained for a most propitious construction of the buckets in accordance with flow techniques in order to attain a high specific rate of revolutions and to make available a high efficiency.

The welded joints connecting the buckets to one another along their inner limiting edges **2** (Figures 1 to 3) lie within zones free from bending, so they are not subjected to undesired strain.

The small diameter of the carrier disc **1**, its moderate axial dimension and the simple connection offer little resistance to the branch jets flowing left and right and also permit an increase of the specific rate of revolutions. This makes it possible to employ free jet turbines where hitherto it was necessary to use Francis turbines.

Due to the special arrangement of the buckets on the carrier disc **1**, in particular when the bucket surface at its central inner portion **5** passes smoothly into the conical surface, further advantages are obtained of a fluid-dynamic character. Thus parts of the carrier disc **1** contribute to the water deflection. In this manner, the carrier disc **1** adds to its own function another supplementary function according to fluid dynamics.

The selection of the angle α at 90° (Figure 3) and less has in connection with the other measures relating to fluid dynamics and stability a practical significance in accordance with fluid dynamics, whereby simultaneously economy of material is obtained as compared with former constructions of said bucket parts.

According to Figure 4, the water is conducted, in the usual manner, as a cylindrical free jet on to the bucket wheel. The water supply may be in the form of multiple free jets or the so-called annular jet.

The embodiment of the bucket wheel of the invention shown in Figures 5 to 7 truly differs in its exterior appearance from the embodiment of Figures 1 to 3 but the features which characterize the invention are also present here. The inner edges **2** of the buckets alternating with their open side toward each side of the wheel are adjacent to the back **3** of the following bucket, whereby the supporting line extends from the border of the peripheral edge **6** in a curve up to the periphery of the double-cone shaped carrier disc **1**.

Contrasting with the embodiment of Figures 1 to 3, the buckets here are positioned close to one another. The extension along the circumference of the carrier disc **1** is greater by the bucket outer parts **15** than by the inner parts. The outer limiting edge **4** of each bucket lies with the inner limiting edge of the subsequent bucket in about the same plane comprising the wheel axle. Further, the outer part **15** of each bucket forms with the inner part **14** of the subsequent bucket pairing surfaces slightly converging. The least distance betweeen the outer part **15** of a bucket and the inner part **14** of the following bucket is to be found in the zone of the outer limiting edge **4**. The peripheral knife-edges **6** of the bucket inner parts **14** form a compact zigzag line. Further, the bucket outer parts **15** also are ending in peripheral knife-edges which lie in a common coaxial cylindrical surface with the knife-edges **6** of the inner parts **14**.

This bucket wheel embodiment is particularly suitable for reaction turbines as can be seen from Figure 8. The bucket wheel is mounted in a casing **16** and provided with two discharges **17, 18**. The water supply is conducted onto the bucket wheel over a spiral casing **19** in direction of arrow **20**.

Owing to the oblique position of the peripheral knife-edges **6** over the bucket partition, the water streaming in direction of the arrows **20** will divide with less shock and the longitudinal oscillation of the impacting water in the pipe is not so easily amplified. The water leaves the bucket on both sides of the bucket wheel without energy in the absolute direction **21**. The direction of the bucket rotation effected thereby is indicated by the arrow **22**.

In applying the bucket wheel of the invention according to the embodiment of Figures 5 to 7, the result is that the reaction turbine will somewhat resemble the Francis twin-turbine, only substantially simplified in that owing to the connection of the buckets to one another and to the carrier disc **1** the hydraulic and centrifugal forces can be transmitted by the buckets only to the impeller, so that the usual base and bucket wreath of Francis wheels are here superfluous.

Another embodiment of a bucket wheel in accordance with the invention is shown in Figures 9 to 11. The difference from the embodiment of Figures 5 to 7 lies in the radial prolongation **23** of the bucket surfaces. This radial prolongation **23** has a breadth of the same size as the breadth of the peripheral knife-edges **6** of the bucket wheel according to Figures 5 to 7.

Figure 12 shows a bucket wheel according to Figures 9 to 11 as used for a reaction turbine. Like in Figure 8 the bucket wheel is mounted in a casing **16** and is provided with two discharges **17, 18**. In the same manner, the water supply is conducted onto the bucket wheel over a spiral casing **19** in direction of arrow **20**. Said spiral casing **19** is connected to the casing **16** over a circular area defined by ring-shaped walls **24**. The radial prolongations **23** of the bucket wheel are extending in said circular area. This measure secures a reliable hydraulic guidance of the streaming water. The arrow **21** shows the direction of discharge of the water discharging without energy. Arrow **22** indicates the direction of rotation of the wheel.

The embodiment according to Figures 9 to 11 is also advantageously suitable for pumps for the delivery of water or air. As shown in Figure 13 the direction of rotation of the wheel and the stream direction are merely reversed. The arrow **25** indicates the direction of rotation of the wheel. The medium to be delivered is supplied in axial direction of the arrows **26** and discharged radially in the direction of the arrows **27** with increased pressure into the spiral casing **19** here acting as a diffuser.

Having thus fully described the invention, what I claim as new and desire to secure by Letters Patent is:

1. A bucket wheel comprising a carrier disc, open buckets having substantially the same wall thickness throughout disposed in staggered arrangement at the periphery of said carrier disc and alternately directed to the right and left with respect to the middle plane of said carrier disc normal to the wheel axle, each bucket being in immediate connection with the back of the following one, the connection of each bucket to the back of the following bucket substantially extending along the entire radial length of said back.

2. A bucket wheel as set forth in claim 1 wherein each bucket is uninterruptedly connected with the neighboring bucket.

3. A bucket wheel as set forth in claim 1, wherein the interior angle of the bucket surface between the outer limiting edge of the buckets and the generatrices of the carrier disc are 90° or less.

4. A bucket wheel comprising a carrier disc, open buckets having substantially the same wall thickness throughout disposed in staggered arrangement at the periphery of said carrier disc and alternately directed to the right and left with respect to the middle plane of said

carrier disc normal to the wheel axle, each bucket being in immediate connection with the back of the following one, the connection of each bucket to the back of the following bucket substantially extending along the entire radial length of said back, the region of strongest curvature of the bucket inner surfaces being at the outer parts of the buckets, the inner parts of said buckets being but slightly inclined towards said middle plane, the bucket inner parts having peripheral edges whereas the bucket outer parts are sloped outwardly.

5. A bucket wheel comprising a carrier disc, open buckets having substantially the same wall thickness throughout disposed in staggered arrangement at the periphery of said carrier disc and alternately directed to the right and left with respect to the middle plane of said carrier disc normal to the wheel axle, each bucket being in immediate connection with the back of the following one, the region of strongest curvature of the bucket inner surfaces being at the inner parts of the buckets, the outer part of one bucket forming with the inner part of the neighboring bucket pairing surfaces slightly converging, the bucket inner parts as well as the bucket outer parts having peripheral edges lying in a common cylindrical surface coaxial with the wheel axle.

6. A bucket wheel comprising a carrier disc, open buckets having substantially the same wall thickness throughout disposed in staggered arrangement at the periphery of said carrier disc and alternately directed to

the right and left with respect to the middle plane of said carrier disc normal to the wheel axle, each bucket being in immediate connection with the back of the following one, the region of strongest curvature of the bucket inner surfaces being at the inner parts of the bucket, the outer part of one bucket forming with the inner part of the neighboring bucket pairing surfaces slightly converging, the bucket inner parts having radial prolongations with peripheral edges which lie in a cylindrical surface coaxial with the wheel axle.

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